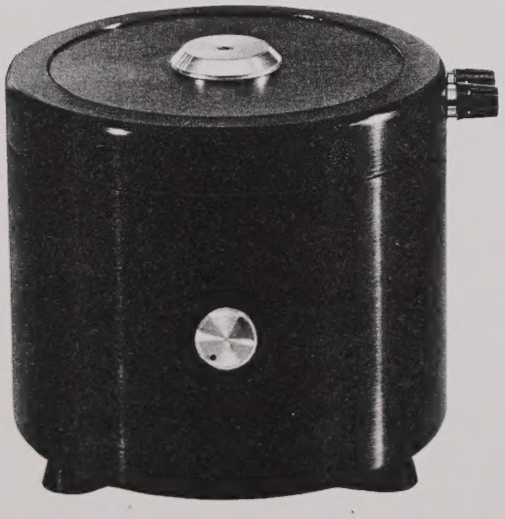
4809

Instruction Manual

PM Vibration Exciter Type 4809



A compact, permanent magnet electro dynamic exciter with force rating of 44,5 N (10 lbf) for vibrating small vibration test specimens at frequencies ranging from 10 Hz up to 20 kHz. Its moving coil has a nominal impedance of 2 Ω with maximum current rating of 5 A RMS. With assisted air cooling the maximum current and force rating may be extended up to 7 A RMS and 60 N (13,5 lbf) respectively.

Brüel & Kjær

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PM VIBRATION EXCITER
TYPE 4809

Revision December 1980

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type 4809

Vibration Exciter

FEATURES:

- Force rating 45 Newton, 10 lbf, Sine Peak (60 N with air cooling)
- Frequency range 10 Hz to 20 kHz
- First axial resonance 20 kHz
- Maximum bare table acceleration 736 m/s², 75 g (981 m/s² with air cooling)

USES:

- Calibration of accelerometers
- Vibration testing of small objects
- Educational demonstrations
- Mechanical impedance measurements

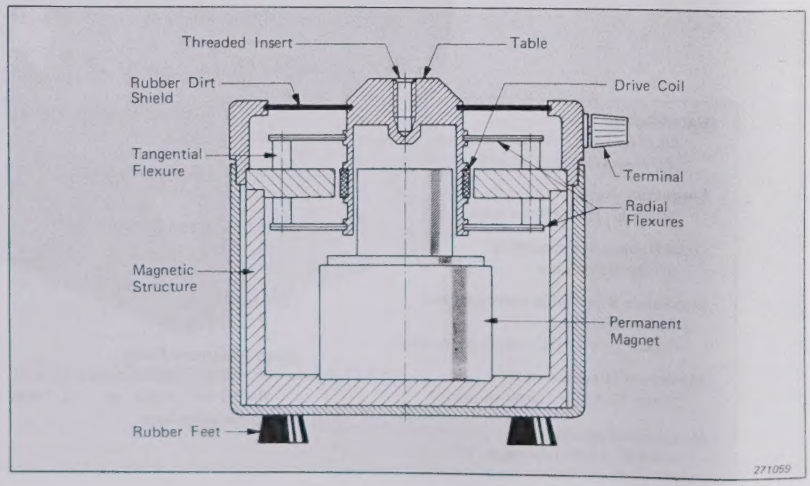

Fig. 1. Sectional drawing of Vibration Exciter Type 4809

The Vibration Exciter Type 4809 is a small versatile machine with an impressive performance. Excellent materials and quality control ensure long term constructional and performance reliability. The 4809 can be driven by any small power amplifier up to a maximum input current of 5 Amperes without assisted cooling. The Brüel & Kjær Power Amplifier Type 2706, rated at 75 VA has been designed to drive the 4809.

Vibration transducers of any type can be calibrated on the 4809, their frequency response can be determined in the frequency range 10 Hz to 20 kHz. For example, the sensitivity calibration of a 21 gram accelerometer can be determined up to a level of 551 m/s², 56 g.

2-044 0231-2A
BP 0231

A Columax permanent magnet provides the high magnetic flux density in the air gap needed to create high force with low amplifier power. The low effective weight of the moving element maximises the acceleration and payload characteristics of the 4809. Maximum bare table acceleration is 736 m/s^2, 75 g. The maximum payload at various acceleration levels is shown in Fig.2.

The moving element is supported by a robust rectilinear guidance system consisting of grouped radial and transverse flexures. The flexures are made from a bonded sandwich of spring steel and a damping elastomer. This flexure system produces a clean acceleration waveform with low cross motion and low distortion characteristics. Axial, transverse, and flexural resonances are highly damped. By careful design of the moving element structure, an extremely high bare table first axial resonance frequency of 20 kHz has been achieved.

A threaded insert is set into the table surface for attachment purposes. The insert is replaceable and acts as a mechanical fuse, protecting the moving element from damage. For most types of abusive treatment the inner threads fail before the moving element is damaged.

A continuous 8 mm, 0,315 inch peak–to–peak displacement is possible; should the Exciter be overdriven, overtravel stops will prevent the displacement becoming excessive.

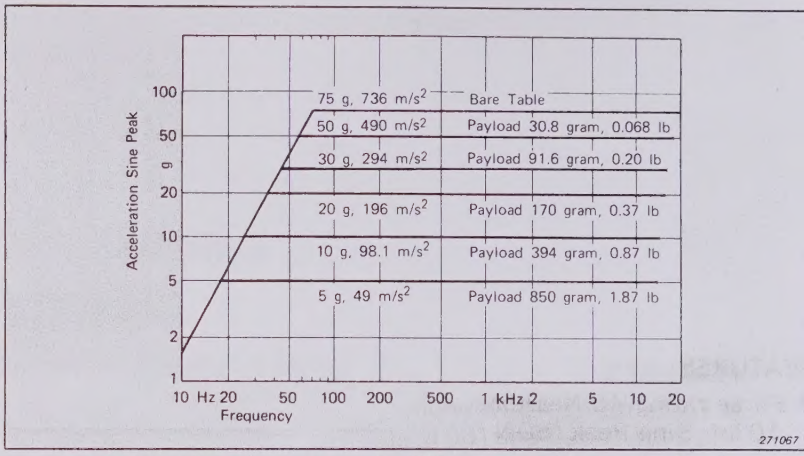

Fig.2. Sine performance curves for the 4809 operating without assisted cooling

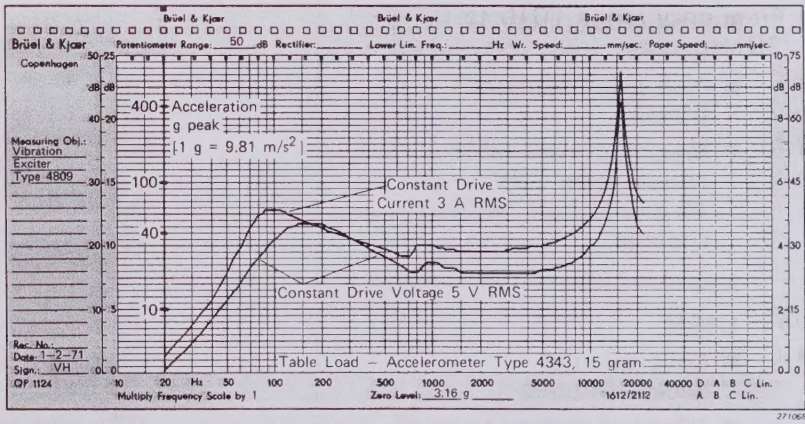
Brüel & Kjær
Copenhagen
Potentiometer Range: 50 dB Rectifier: Lower Lim. Freq.: Hz Wr. Speed: mm/sec. Paper Speed: mm/sec.
400 Acceleration g peak (1 g = 9.81 m/s²)
100
40
10
Constant Drive Current 3 A RMS
Constant Drive Voltage 5 V RMS
Table Load – Accelerometer Type 4343, 15 gram
Measuring Obj.: Vibration Exciter Type 4809
Rec. No.:
Date: 1–2–71
Sign.: VH
QF 1124
10 20 Hz 50 100 200 500 1000 2000 5000 10000 20000 40000
Multiply Frequency Scale by 1
Zero Level: 3.16 g
1612/2112
271068

Fig.3. Constant voltage and constant frequency response of the 4809

Either of the two grooved spigots in the body may be unscrewed and replaced by a compressed air line nipple to facilitate low pressue air cooling of the drive coil and flexures. With cooling air supplied at an inlet pressure of 100 kPa (1 kp/cm^2 or 14,7 lbf/in^2) the input current may be raised to 7A RMS which results in an increase in the force rating to 60N (13,5 lbf).

A complete range of instrumentation is available for use with the 4809. This includes control generators, power and measuring amplifiers, accelerometers, preamplifiers, frequency analyzers and level recorders.

Specifications 4809

Rated Force:
44,5 Newton, 10 lbf Sine Peak
(60 Newton, 13,5 lbf with air cooling)

Frequency Range:
10 Hz to 20 kHz Bare table

Axial Resonant Frequency:
20 kHz Bare table

Maximum Bare Table Acceleration:
736 m/s^2 (75 g)
(1000 m/s^2, 100 g, with air cooling)

Maximum Displacement:
8 mm (0,315 in) peak-to-peak

Maximum Velocity:
1,65 m/s (65 in/s) peak

Dynamic Weight of Moving Element:
60 gram (0,132 lb)

Dynamic Flexure Stiffness:
12 Newton/mm (69 lb/in)

Maximum Input Current:
5 A RMS
(7 A RMS with air cooling)

Coil Impedance:
2 Ω at 500 Hz

Stray Magnetic Field:
20×10^{-3} tesla at table face
8×10^{-3} tesla at 12,7 mm (0,5 in) above table face

Table Size:
29 mm (1,14 in) diameter

Fastening Thread:
5 × 5/16″ – 18 UNC for M5 and 10-32 inserts

Total Weight:
8,3 kg (18,3 lb)

Dimensions:
Diameter: 149 mm (5,87 in)
Height: 143 mm (5,63 in)

Accessories Included:
Thread inserts (M5) ..... YS 0810
Thread inserts (10-32) ..... YS 0811
Insert mounting tool ..... QA 0061

2. OPERATION

2.1. COOLING

Vibration Exciter Type 4809 has a rated current of 5 A RMS, which with assisted air cooling may be extended up to 7 A RMS. Without assisted cooling operation at 5 A RMS will cause the vibration table to become hot, but will not damage the Exciter. If the temperature rise is likely to influence temperature sensitive vibration test specimens or vibration transducers then assisted air cooling should be employed.

The most efficient method of cooling is to blow air into the Exciter via one of the blanking holes on the side of the Exciter body. These are normally covered by a screw insert and have a 12 mm diameter, 1,75 mm pitch thread for connection of compressed air fittings. The blanking hole not in use should be left with its screw insert fitted. If the air pressure causes the vibration table to rise more than 1 mm above its normal level then the insert should be partially unscrewed to regulate the pressure.

2.2. EXCITER MOUNTING

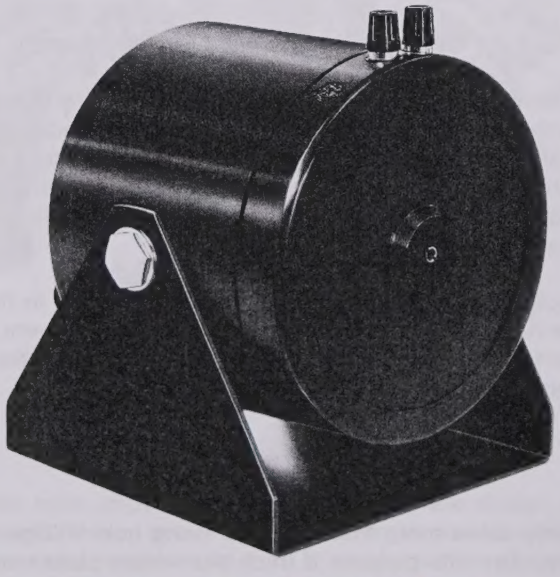

Fig.2.1. Mounting of 4809 Exciter

For accelerometer calibration or testing of small vibration test objects up to 1 Kg (2,2 lb the 4809 can be used in an upright position, standing on its three rubber feet. For use in other positions it may be mounted on a metal stand such as that shown in Fig.2.1. In this case the Exciter may be bolted to the stand using the screw inserts provided with the blanking holes on either side of the Exciter body. For suspension of the Exciter from cables or ropes, a groove is cut into each insert.

2.3. MOUNTING VIBRATION TEST OBJECTS

The vibration table of the 4809 is provided with a single fixing hole. This is has an 1 UNC tapped thread and is 6,8 mm (0,27 in) deep. To prevent damage to the table, vibration test objects should be mounted with their centre of gravity in line with this hole. Also, avoid fastening test objects directly to the fixing hole — use the threaded insert provided.

2.3.1. Threaded Inserts

For fastening vibration test objects the 4809 is provided with five threaded inserts YS 0811. These convert the 18 UNC thread of the vibration table fixing hole to a 10 — 32 NF thread and act as mechanical fuses which strip their inner thread before excessive force or mounting torque can damage the vibration table fixing hole. The correct mounting torque is approximately 0,35 Kg m (30 lb in) which is best applied using a torque wrench for screwing test objects or fixtures onto the vibation table.

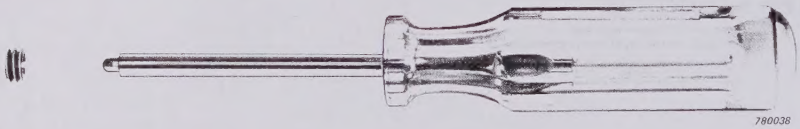

Fig.2.2. Threaded insert YS 0811 and mounting tool QA 0061

For fitting inserts the mounting tool QA 0061 is provided. This has a locating pin at the end of its screw blade which fits into the threaded hole of the inserts so as to prevent side slippage of the tool when screwing them into the vibration table. When properly fitted the top of the inserts should be approximately 0,1 mm (0,004 in) below the top of the table. Never bottom an insert in the fixing hole and always ensure that the insert as well as the hole are thorougly clean.

To lock an insert apply a small drop of adhesive to the outer thread of the insert before screwing it down. A suitable thread locking cement is loctite IS (B & K no. QS 0003 which is provided. For unscrewing a locked insert, the cement may be weakened using a soldering iron to heat up the insert.

2.3.2. Test Fixtures

In many cases more than just one fixing hole will be required for mounting vibration test objects. For this purpose a thick aluminium plate may be made which has the appropriate fixing hole arrangement for fastening the test specimen. The plate may then be screwed onto the exciter via the fixing hole at the centre of the vibration table. To prevent plate resonances influencing the vibration response of the test specimen the dimensions of the mounting surface of the plate should be kept as small as possible.

2.3.3. Pushrods

For vibration mode studies on panels or other structures, it is generally convenient to have a driving point a short distance away from the Exciter. For this purpose a pushrod such as that shown in Fig.2.3 may be used to transfer the force from the fixing hole at the centre of the vibration table.

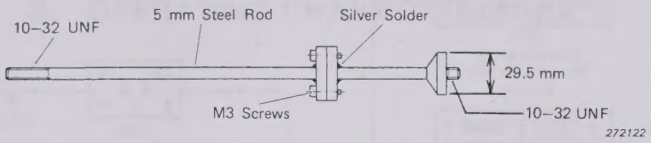

Fig.2.3. Typical pushrod for use with the 4809 Exciter

Fig.2.4 shows a push rod in use for transmitting force to a gas measuring device in the laboratory of a soft drink manufacturer. The gas measuring apparatus and bottle holding jig are free to move horizontally on rollers, whilst the push rod transmitting the force is attach to the fixture via a locking pin so as to permit frequent removal of the fixture.

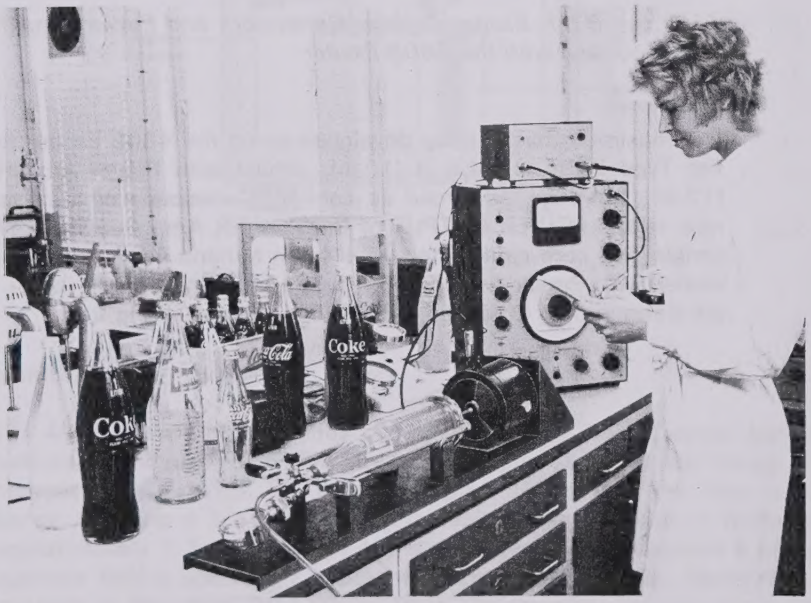

Fig.2.4. Horizontal vibration fixture using pushrod to transmit force from the 4809 Exciter

One of the most important considerations in the design of a pushrod is its useful frequency range. This is determined by its length and its stiffness as well as by the velocity of sound in the particular material. If a reduction in operating frequency can be tolerated then the stiffness of the rod may be reduced so as to help protect the Exciter. Excessive side loads or side movements will then cause bending of the rod rather than rubbing of the vibration table drive coil against the pole piece of the Exciter.

2.4. CONNECTION OF POWER AMPLIFIER

The range of B & K Exciter Control Generators and Amplifiers which may be used with the 4809 is shown in Fig.2.5.

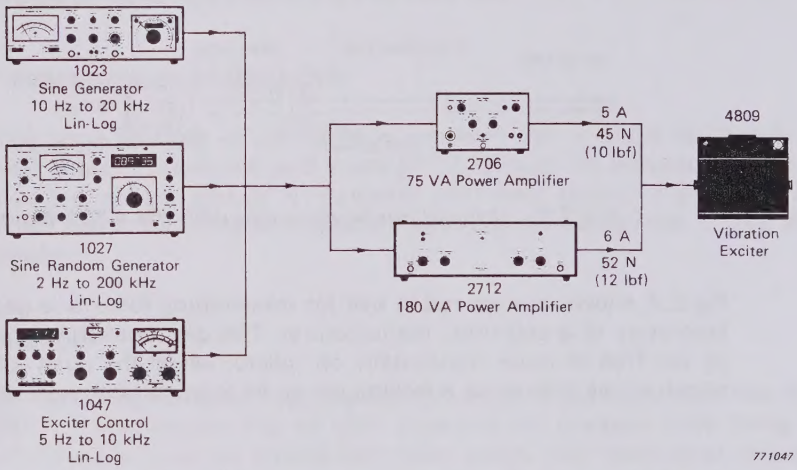

Fig.2.5. B & K Exciter Control Generators and Power Amplifiers for use with the 4809 Exciter

The maximum force rating developed using the 4809 Exciter together with Power Amplifier Type 2706 is 44,5 N (10 lbf), whilst with Power Amplifier Type 2712 it is 52 (12 lbf), but requires forced air cooling. Connection of the Exciter POWER INPUT terminals to the POWER OUTPUT of the POWER Amplifier Type 2706 can be made using simple two core cable fitted with 4 mm banana plugs (B & K no. JB 0002) at both ends whilst with Power Amplifier Type 2712 one end of the cable should be fitted with a pin Cannon plug (B & K no. JP 0308) as shown in Fig.2.6.

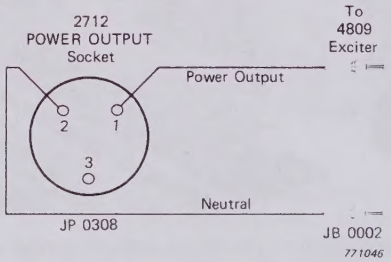

Fig.2.6. Drive cable for connection of the 4809 Exciter to Power Amplifier Type 2712

3. OPERATING CHARACTERISTICS

3.1. CONSTRUCTION

A sectional view of the 4809 vibration Exciter is shown in Fig.3.1.

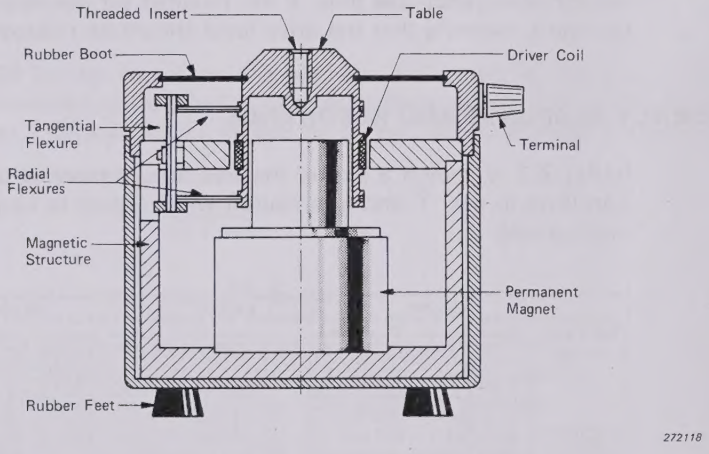

Fig.3.1. Vibration Exciter Type 4809

3.1.1. Magnet Assembly

The 4809 has a Columax alloy permanet magnet. This is expoxy bonded to the base of a cast iron structure, at the top of which is mounted a cast iron flange. From the magnet a high purity, cylinderical, iron pole piece projects up into the hole at the centre of the flange, creating a 1,4 mm (0,055 in) wide, circular air gap in which a magnetic field of approximately 1 Tesla (10^4 gauss) is produced. To help ensure a uniform gap and homogenous field a special jig is used for centring the flange. Above the table top the field strength is less than 20×10^{-3} Tesla and therefore will not harm sensitive equipment and wrist watches used near the Exciter.

3.1.2. Moving Element

The moving element is a thin hollow cylinder with a vibration table at one end and a drive coil at the other. It is designed to provide the best possible coupling between the force generated by the drive coil and the test object on the vibration table. For maximum bare table acceleration and a high resonance frequency it is machined from a light weight aluminum solid. Its vibration table is lapped and hardened by a deep electrochemical process so as to provide a smooth durable coupling with test objects.

The drive coil mounted at the bottom of the moving element is made up of two paralle windings. These are coupled to two terminals on the side of the Exciter body and have a nominal impedance of 2 Ω at 500 Hz. Their maximum drive current rating is 5 A RMS but with assisted air cooling as in section 2.1 may be extended up to 7 A RMS.

The moving element is supported in the field gap of the magnet assembly by two sets o triaxial flexures. These are in turn mounted on tangential flexures and accurately alig the moving element with its drive coil centred in the gap, allowing it to move up an down without twisting or rubbing against the sides of the gap. Each flexure is a sand wich of spring steel plate bonded with rubber that helps damp the resonance modes o the suspension.

The maximum displacement limit of the moving element is 8 mm (0,315 in) peak t peak. Rubber stops, mounted above and below the gap, help protect the element fro overtravel. The stops are designed to receive the occassional high velocity impact an are for emergency use only. If the flexures hit the stops an audiable bumping sound wi be heard, warning that the drive level should be reduced immediately.

3.2. FREQUENCY RESPONSE AND RESONANCE

In Fig.3.2 is shown a plot of the frequency response of the 4809 Exciter. The accelera tion level in ms^{-2} and g is plotted with respect to frequency for a constant drive voltag and current.

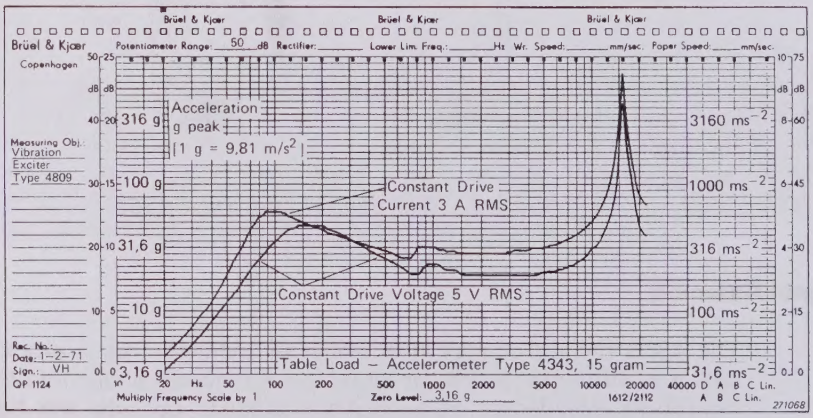

Fig.3.2. Typical frequency response of 4809 Exciter

The acceleration level increases with frequency to a damped peak at 150 Hz. This is th suspension resonance of the Exciter. The acceleration level then remains constant fro 700 to 5000 Hz, after which it climbs sharply to a peak at 16 kHz. This peak is the ma jor axial resonace of the moving element itself. It can be seen that the Exciter may b operated at frequencies between 700 and 5000 Hz without using a compressor loop t control the level of the drive signal. However, the use of a compressor loop is generall recommended, since resonances in the particular vibration test object used must b taken into account.

3.3. FORCE RATING AND OTHER OPERATION LIMITS

The force required to vibrate a mass "m" with an acceleration "a" is given by:

$$F = ma$$

By rearanging and including the effective mass "m_e" of the Exciter's moving element, we obtain:

$$a = \frac{F}{m + m_e}$$

from which the maximum acceleration of the Exciter with any payload may be calculated.

Example.

The 4809 Exciter has a moving element with effective mass $m_e = 0{,}06$ kilogram, which without assisted cooling has a maximum force rating of 44,5 Newton. The maximum acceleration produced when loaded by a test object of mass $m = 0{,}165$ kilogram is given by:

$$a = \frac{F}{m + m_e}$$

$$a = \frac{44{,}5}{0{,}165 + 0{,}06}$$

$$a = 200\ \text{ms}^{-2} \text{ or } 20{,}38\ \text{g}$$

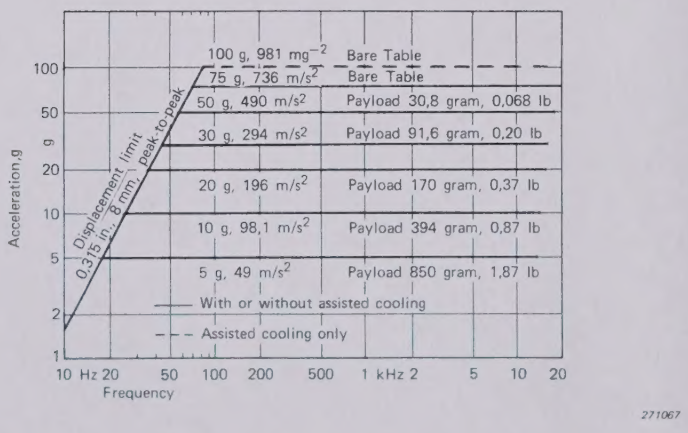

Fig.3.3. Performance limits for sine operation of the 4809 Exciter with and without assisted cooling

The maximum acceleration with other loads can be determined for the load rating curves given in Fig.3.3. At frequencies above 70 Hz the limits are based solely on the amount of force available. However, for a given acceleration level displacement increases as frequency decreases. Therefore at frequencies up to 70 Hz the Exciter must be held to its 8 mm (0,315 in) maximum displacement limit, to avoid hitting the end stops.